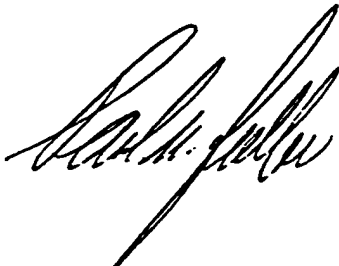


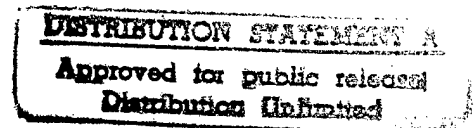
Report of the  
COMSTAC Technology & Innovation Working Group

**COMMERCIAL SPACECRAFT MISSION MODEL UPDATE**

25 July 1996



**Paul Fuller, Chairman**  
**Technology & Innovation Working Group**



Commercial Space Transportation Advisory Committee (COMSTAC)  
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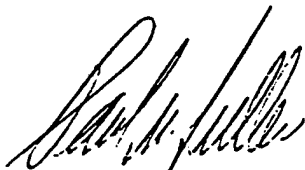
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## COMMERCIAL SPACECRAFT MISSION MODEL UPDATE

### Introduction

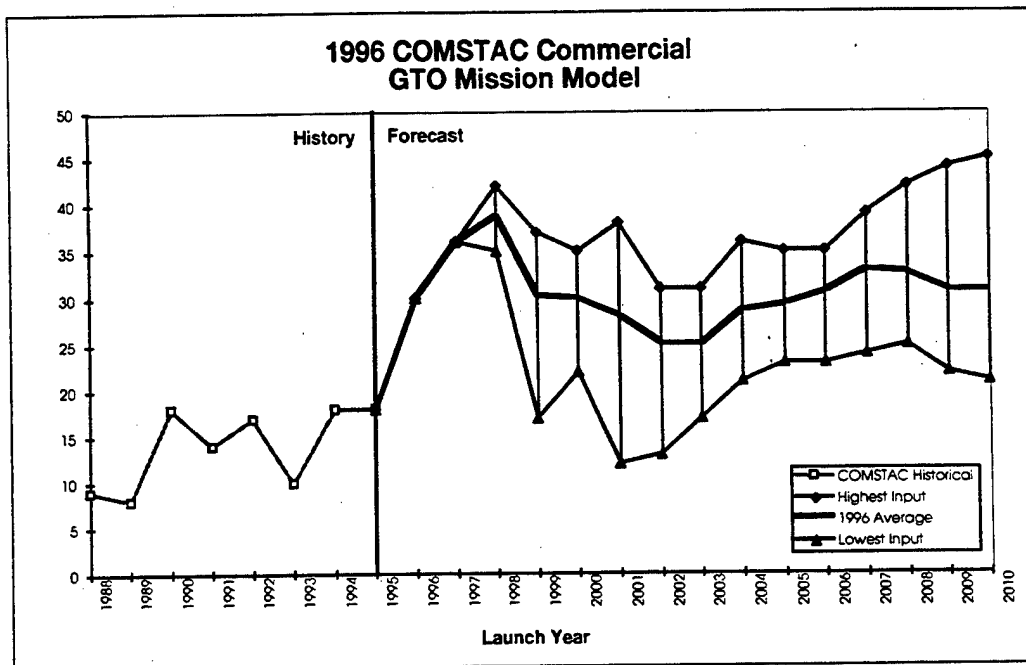
The U.S. Department of Transportation's Office of Commercial Space Transportation (DoT/OCST) of the Federal Aviation Administration (FAA) endeavors to foster a healthy commercial space launch capability in the United States. An important element of these efforts is to establish the commercial space industry's view of future space launch requirements. Since 1993, the OCST has requested that its industry advisory group, the Commercial Space Transportation Advisory Committee (COMSTAC), prepare and maintain a commercial spacecraft launch demand mission model.

This report presents the 1996 update of the worldwide commercial Geosynchronous Transfer Orbit (GTO) satellite mission model for the period 1996 through 2010. It is based on market forecasts obtained in early 1996 from major spacecraft manufacturers, satellite operators and launch service providers. There are two key points regarding the mission model forecast. First, the mission model is limited to "addressable" payloads, those which are open to internationally competitive launch service procurement. Captive payloads to national flag carriers are excluded from the mission model. Secondly, the number of launches per year resulting from this spacecraft mission model will be a subset of this data due to the potential for multiple manifesting on one or more launch vehicles. The Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) market forecasts have been developed by the DoT/OCST separately from this report (reference 1).

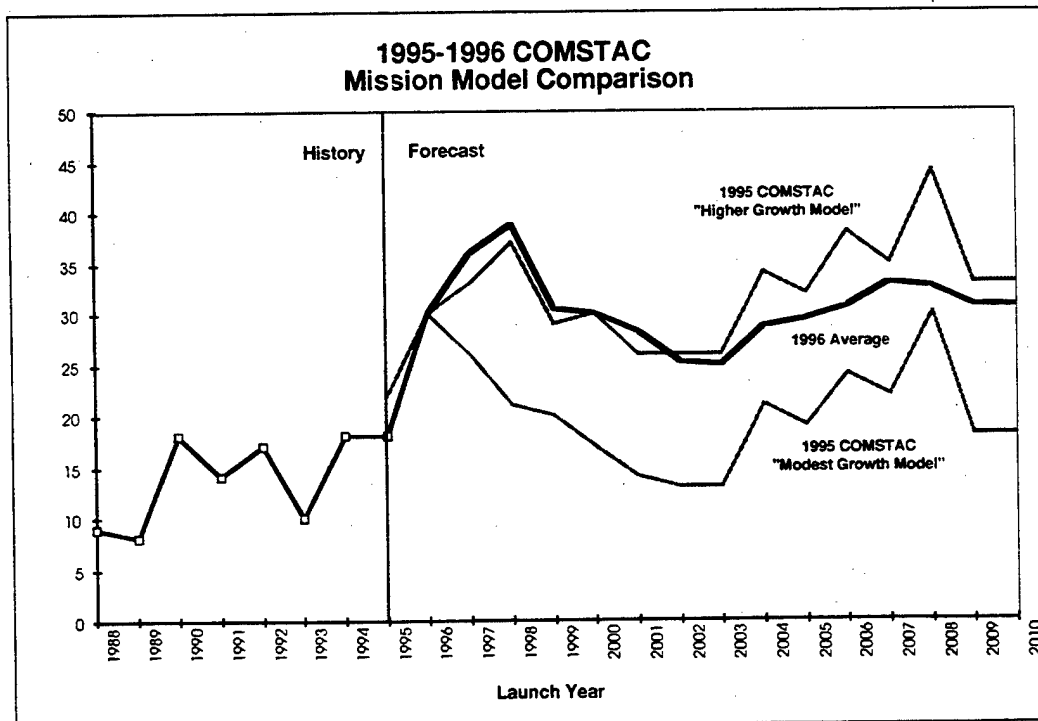
### 1996 Mission Model Update Methodology

Through a process similar to that in 1995, the Technology and Innovation Working Group solicited input from industry via a letter sent over the signature of the Associate Administrator for Commercial Space Transportation (reference 2). The letter requested market projection data representing the best forecast of the number of addressable commercial GTO payloads per year in the period 1996 - 2010. "Addressable" payloads were defined as those that are open to competitive launch service procurements by U.S., European and other foreign launchers. Excluded were payloads predetermined to be manifested on national flag launch service providers, including government owned payloads, such as DoD and NASA missions, or similar European, Chinese or other nationally captive spacecraft. A table was provided for the respondents to complete which segregated the payloads into categories of "Medium", "Intermediate" and "Heavy" based on separated mass inserted into GTO. In order to accommodate the new launcher initiatives of Delta III and Atlas IIAR, which are considered as Intermediate class given their initial performance characteristics, this class was extended by 1,000 lbs to 9,000 lbs as indicated in the table below. In previous years "Intermediate" was defined as 4,000 lbs to 8,000 lbs.

Launch Capability (lbs to GTO)	Classification
2000-4000	Medium
4000-9000	Intermediate
>9000	Heavy



**Figure 1.0 1996 COMSTAC Commercial GTO Mission Model**



**Figure 2.0 1996-1996 Mission Model Comparison**

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In 1996, commercial spacecraft launch demand data provided by the following organizations were used in the development of this report:

Boeing Company	Lockheed Martin ILS
COMSAT	McDonnell Douglas Aerospace
CTA	Motorola
GE Americom	Orbital Sciences
Hughes Space and Communications	Space Systems Loral
INMARSAT	TRW
INTELSAT	

## Conclusions

The following conclusions are based on the results of this 1996 update of the worldwide commercial GTO mission model:

- The 1996 COMSTAC Commercial Mission Model (Figure 1.0) indicates annual demand for launch of commercial GTO payloads will likely be approximately 31 per year in the period 1996 - 2010. While the high-low dispersions reflect uncertainty in the predictability of the market, it was agreed that the aggregate average is representative of general market forces and trends.
- There is industry-wide convergence toward the 1995 Higher Growth model through 2003. The average of the out year estimates is midway between the 1995 Higher and Modest Growth projections (Figure 2.0). Unlike 1995, the 1996 inputs were not grouped into two distinct higher and modest growth positions. The emergence of new Ka broadband systems and growth in GEO mobile systems may have contributed to the growth in the market forecast.
- The satellite and launch vehicle industry is experiencing a period of significant growth throughout the latter part of the decade. A modest decline beginning in 1998 is expected to be followed by a second wave of growth beginning around 2004 as replenishment of the current generation of active satellites begins.
- The mass of commercial payloads is likely to stay the same or grow, and the mass distribution can best be summarized by two cases:
  - The Stable Mass Growth model predicts that mass trends may have peaked or could stabilize over the next few years.
  - The Continued Mass Growth model predicts steady and continued payload mass growth, generally in line with historical precedent.

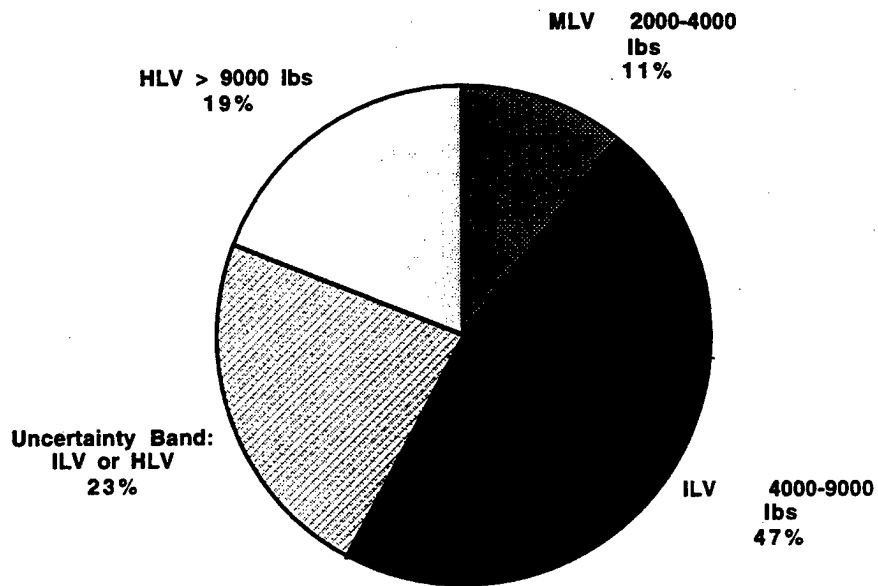
These trends are shown in Figure 3.1 and summarized below. In both cases the number of Medium payloads is approximately 11% of the market. The "ILV or HLV" portion of the graph reflects the difference between the two models.

Stable Mass Growth Model		Continued Mass Growth Model	
MLV	11%	MLV	11%
ILV	70% (23% + 47%)	ILV	47%
HLV	19%	HLV	42% (19% + 23%)

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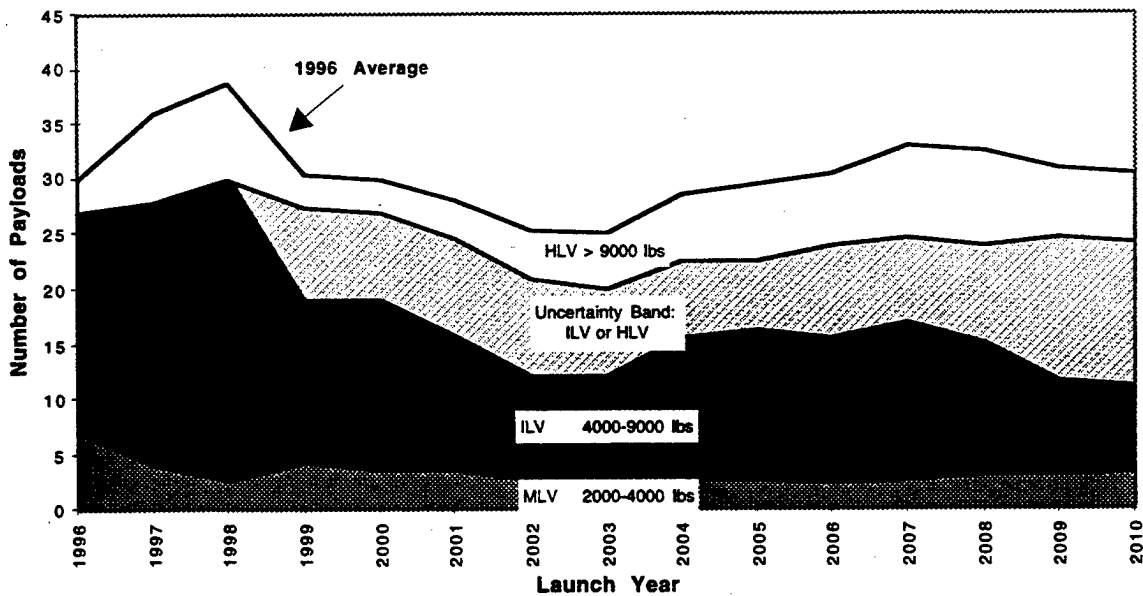
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### Average Payload Mass Distribution 1996-2010 (Stable and Continued Mass Growth Models)



**Figure 3.1** Average Payload Mass Distribution 1996-2010, comparing stable and continued payload mass growth models.

### Trends in Annual Payload Mass Distribution 1996-2010 (Stable and Continued Mass Growth Models)



**Figure 3.2** Trends in Annual Payload Mass Distribution 1996-2010, comparing stable and continued payload mass growth models.

- In the case of the Continued Mass Growth Model, a significant number of payloads are forecasted to exceed the capability of current U.S. launchers.

Several factors may influence the evolution of payload mass over time (Figure 3.2). These include the introduction of several new heavy-lift launch vehicles, the increased cost effectiveness of larger spacecraft (on a dollars per transponder basis), increasing spacecraft power requirements, and increased orbital congestion. The impact of these factors, along with the potential use of electric propulsion for orbit-raising, may determine whether the market evolves consistently with the Stable Mass Growth case or the Continued Mass Growth case.

### **Recommendations**

The following are the recommendations based on the implications of this 1996 update of the worldwide commercial mission model:

- U.S. launcher programs and initiatives should include a >9,000 lb. capability to maximize commercial market viability.
- The 1996 COMSTAC Mission Model forecast should be provided to appropriate U.S. government agencies for their use.

Reference Tables 1.0, 2.1, 2.2 and 2.3 for complete tabular data.

Please refer to Appendix 1 for the detailed 1996 Discussion and Results, Appendix 2 for the 1996 through 1998 Near-Term Mission Model, and Appendix 3 for the 1988-1995 Payload Launch History.

### **References**

1. Department of Transportation letter, "LEO Market Study", dated 2/02/96, F. Weaver
2. Depart of Transportation Letter, date 2/20/96, F. Weaver



**TABLE 1.0\* 1996 COMSTAC COMMERCIAL GTO MISSION MODEL SUMMARY**

<b>CONSTAC 1996 Summary</b>	<b>96</b>	<b>97</b>	<b>98</b>	<b>99</b>	<b>00</b>	<b>01</b>	<b>02</b>	<b>03</b>	<b>04</b>	<b>05</b>	<b>06</b>	<b>07</b>	<b>08</b>	<b>09</b>	<b>10</b>	<b>Total 1996- 2010</b>	<b>Avg 1996- 2010</b>
Highest Input	30	36	42	37	35	38	31	31	36	35	35	39	42	44	45		
<b>Average Rate</b>	<b>30</b>	<b>36</b>	<b>40</b>	<b>31</b>	<b>30</b>	<b>29</b>	<b>25</b>	<b>25</b>	<b>29</b>	<b>30</b>	<b>31</b>	<b>33</b>	<b>33</b>	<b>31</b>	<b>31</b>	<b>464</b>	<b>31</b>
Lowest Input	30	36	35	17	22	12	13	17	21	23	23	24	25	22	21		

**\* Notes:**

- 1) The "Average Rate" 1996 COMSTAC forecast represents the sum of all forecast launch rates divided by the number of all forecasts provided.
- 2) The "Highest" and "Lowest" inputs reflect the maximum and minimum individual estimates provided for any one year. No working group member's forecast was consistently higher or lower than the "Average" throughout the forecast period.
- 3) The highest contractor estimate was 523 addressable payloads to be launched from 1996 through 2010. The lowest was 380 and the average was 464.
- 4) 1996 and 1997 figures reflect the consensus forecast developed by the working group members and is provided in detail in Appendix 2, "1996 COMSTAC GTO Commercial Mission Model." 1998 figures represent the highest, average, and lowest mix of potential of launch opportunities consistent with Appendix 2, 1998.

**TABLE 2.1\*\* FORECAST TRENDS IN PAYLOAD MASS DISTRIBUTION, "MASS  
GROWTH STABILIZATION MODEL"**

Stable Mass Growth Model	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	Total 1996- 2010	Avg 1996- 2010	Avg 1996- 2010
MLV 2000- 4000 lbs	7	4	3	4	4	4	3	3	3	3	3	3	3	3	3	53	4	11%
ILV 4000- 9000 lbs	20	24	28	24	23	21	18	17	20	20	21	22	21	22	22	323	21	70%
HLV > 9000 lbs	3	8	9	3	3	4	4	5	6	7	7	8	9	6	6	88	6	19%
<b>Total</b>	30	36	40	31	30	29	25	25	29	30	31	33	33	31	31	464	31	

\* Notes:

- 1) MLV = The sum of all forecast launch rates divided by the number of all forecasts provided for this mass category.
- 2) ILV = Total average launch rate less (MLV + HLV).
- 3) HLV = The sum of the three least aggressive HLV mass growth forecasts divided by three.

**TABLE 2.2\*\* FORECAST TRENDS IN PAYLOAD MASS DISTRIBUTION, "CONTINUED  
MASS GROWTH MODEL"**

Continued Mass Growth Model	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	Total 1996- 2010	Avg 1996- 2010	Avg 1996- 2010
MLV 2000- 4000 lbs	7	4	3	4	4	4	3	3	3	3	3	3	3	3	3	53	4	11%
ILV 4000- 9000 lbs	20	24	28	15	15	12	9	9	13	14	13	14	12	9	8	215	14	47%
HLV > 9000 lbs	3	8	9	12	11	13	13	13	13	13	15	16	18	19	20	196	13	42%
<b>Total</b>	30	36	40	31	30	29	25	25	29	30	31	33	33	31	31	464	31	

\*\* Notes:

- 1) MLV = Same as Stable Mass Growth Model above.
- 2) ILV = Total average launch rate less (MLV + HLV).
- 3) HLV = The sum of the two most aggressive HLV mass growth forecasts divided by two.

**TABLE 2.3\*\*\* FORECAST TRENDS IN PAYLOAD MASS DISTRIBUTION, COMBINED  
STABLE AND CONTINUED MASS GROWTH MODEL COMPARISON**

Continued Stable & Continued Mass Growth Model											Total 1996- 2010	Avg 1996- 2010	Avg 1996- 2010					
	96	97	98	99	00	01	02	03	04	05				06	07	08	09	10
MLV 2000-4000 lbs  ILV 4000-9000 lbs  ILV or HLV  HLV > 9000 lbs	7	4	3	4	4	4	3	3	3	3	3	3	3	3	3	53	4	11%
	20	24	28	15	15	12	9	9	13	14	13	14	12	9	8	215	14	47%
	0	0	0	9	8	9	9	8	7	6	8	8	9	13	14	108	7	23%
	3	8	9	3	3	4	4	5	6	7	7	8	9	6	6	88	6	19%
Total	30	36	40	31	30	29	25	25	29	30	31	33	33	31	31	464	31	

\*\*\*  
Notes:

- |               |   |   |
|---------------|---|---|
| 1) MLV        | = | Same as MLV from both Stable and Continued Mass Growth Models above.                            |
| 2) ILV        | = | Same as ILV from Continued Mass Growth Model above.   |
| 3) ILV or HLV | = | Continued Mass Growth Model ILV forecast less Stable Mass Growth HLV forecast as defined above. |
| 4) HLV        | = | Same as HLV from Stable Mass Growth Model above.  |

### Examples of Mass Category Definitions:

- 1) **MLV** Atlas I, Delta II, Long March 3 and 3A, co-passenger payloads on Ariane 4 or 5 and H2 launch vehicles.
- 2) **ILV** Atlas II, IIA, IIA, IIR, Delta III, dedicated H2, Sea Launch Zenit, Proton D1e and co-passenger payloads on Ariane 4 or 5 launch vehicles.
- 3) **HLV** Dedicated Ariane 4 or 5, Long March 3B, Proton D1e, and Sea Launch Zenit.

Report of the  
COMSTAC Technology & Innovation Working Group

**COMMERCIAL SPACECRAFT MISSION MODEL UPDATE**

**May 1996**

**Appendix 1**  
**1996 Discussion and Results**

Commercial Space Transportation Advisory Committee (COMSTAC)  
Office Of Commercial Space Transportation  
Federal Aviation Administration  
U.S. Department of Transportation

## 1996 DISCUSSION AND RESULTS

The 1996 mission model is made up of two key elements: (1) Payload Launch Demand Forecast: the number of payloads available for launch per year (not adjusted for possible multiple manifesting) and (2) Mass Distribution Forecast: classification of payloads among the launch vehicle categories as described previously in the report. The findings in each of these areas are presented below.

### Payload Launch Demand Forecast

A summary of the forecast of payload launch demand GTO Mission Model for the years 1996 to 2010 is shown Figure 1.0 (refer to the body of the report for all figures). The display represents the aggregate average of all responses plotted against the range of dispersions. The dispersions reflect the highest and lowest data points in each given year. The 1996 forecasts of the numbers of payloads to be launched varied greatly, as the dispersions suggest, however, there was convergence among a significant number of working group members around the average, particularly in the early years of the forecast period. It is important to note that the 1996 data forecasts were not polarized around two viewpoints regarding market growth, as in the 1995 model. Consequently, there was agreement among the participants that the aggregate average can be used as a representative means of portraying the general market forces and trends.

The approach used by the industry to forecast the commercial satellite demand includes evaluating firm contracted missions, current satellite operators planned missions, current operator's replacement missions, current operators growth and growth replacement, as well as "attrition" and some assessment of "unidentified" growth. Attrition is assumed to be 10% of annual launch demand. It includes on-orbit satellite and launch vehicle failure rate, with the demand replaced two years after failure. Unidentified growth includes proprietary, company specific information on future market demand. Differing opinions on the unidentified growth play a key role in the variance in the data toward the outyears of the model.

The plot of the 1996 aggregate average forecast against the 1995 model is depicted in Figure 2.0. The data suggests that since the time of the 1995 report, there is a greater consensus and more confidence in the 1995 Higher Growth model through the early 2000 timeframe. The forecast then remains about midway between the two 1995 cases for the remainder of the period. Events such as the Ka broadband program FCC filings in October 1995 and the emergence of GEO mobile systems may underlie this change since the 1995 report.

The number of payloads actually launched in 1995 (18) was lower than the demand predicted (22) in the 1995 report. A mission by mission assessment indicates that 4 payloads were delayed from 1995 into early 1996, two on Ariane, one on Delta and one on Long March. Typically, these delays are due to a combination of effects including failure-related launcher delays, satellite readiness, and customer preference.

The average rate over the 15 year planning period represents an annual demand of 31 payloads per year (Table 1.0). This is slightly below the 1995 Higher Growth average of 31.8, but significantly above the Modest Growth average of 20.5. The effect of averaging also results in a smoother forecast than that portrayed in 1995, however, the cyclical nature of this market is still noticeable in the data. A dip in the early 2000 timeframe is followed by resurgence of demand in the period 2003 to 2008, typically reflective of replenishment requirements, which is consistent with, but not as marked as in the 1995 forecasts.

The 1996 Arianespace mission model published in March (reference 1) included both Maximum and Nominal forecasts of the period 1996 through 2003. Both are significantly higher than their previous estimates of an average of approximately 15 payloads per year. The 1996 Arianespace Maximum generally tracks closely with the COMSTAC 1996 industry average although their

forecast is slightly lower than COMSTAC in the first two years; the Nominal forecast is generally 5-10 payloads lower than the 1996 COMSTAC average in the years 1999-2003.

### **Graphs and Calculations (Demand)**

The 1996 COMSTAC Mission Model was based on all of the inputs received from the 13 organizations listed in the Methodology. Of those inputs, five inputs were comprehensive and covered the entire addressable commercial GTO market. The remaining inputs were used to verify missions and dates in the five comprehensive mission model forecasts. Accordingly, these five comprehensive mission models provided the basis for all the calculations summarized in this report.

The average launch rate from 1996 through 2010 rate was calculated by adding the five comprehensive working group forecasts together and dividing them by five (Figure 1.0 and Table 1.0). Estimates for 1996 and 1997 reflect the consensus forecast developed by the working group and are provided in detail in Appendix 2, "1996 COMSTAC Commercial GTO Mission Model."

Estimates for 1998 reflect varying estimates of launch rate demand, with a high of 42 and a low of 35, out of the total of 48 potential programs listed in Appendix 2. These differences stem from independent assessments of the likelihood or timing of the unassigned or spacecraft "not ordered" programs annotated in Appendix 2.

The highest and lowest inputs (shown in Figure 1.0 and Table 1.0) represent the single highest or lowest estimated number of payloads to be launched in that year. No working group member's forecast was consistently higher or lower than the "Average" throughout the forecast period. Therefore, the maximum inputs and minimum inputs are not additive. Accordingly, the highest single cumulative estimate across the 1996-2010 forecast period was 523 addressable commercial payloads to be launched. The lowest cumulative estimate was 380 and the average was 464.

### **Mass Distribution Forecast**

Figures 3.1 and 3.2 reflect a significant issue addressed by the working group: How far and how fast will trends in commercial satellite payload mass evolve?

The working group had two answers to the question, with one group predicting that payloads are likely to continue to grow, generally in line with their historical track record, and another group advocating that weight trends may have peaked or could stabilize over the next few years.

It is interesting to note that in either case, in contrast to many U.S. government-funded programs where funding considerations may drive payload mass down, the working group agreed that commercial satellites are likely to stay roughly the same size or even grow.

Some continued growth advocates suggested that a significant, unanticipated market correction was underway and that one-half to two-thirds of addressable commercial payloads could weigh well over 9,000 lbs within the next five to ten years. Other continued growth advocates suggested a more moderate evolution, with about one-third of all new programs weighing over 9,000 lbs by the year 2000. A steady, but gradual evolution could occur thereafter, with roughly half the market weighing over 9,000 lbs by 2006.

Likewise, some members of the "stable growth" group believed that there would be little to no growth, while others advocated that there was likely to be at least some growth, but not necessarily significant. In all cases some payload mass growth is masked by the broadening of the intermediate payload class from 4,000-8,000 lbs to 4,000-9,000 lbs.

Continued growth advocates pointed out, however, that there was more than one reason satellites could continue to grow. Principle among their arguments is the commercial introduction of several new and powerful international launch service systems: the French Ariane 5, the Russian Proton, the Chinese Long March 3B and the Sea Launch program. Each of these systems may not prove successful in its own right as planned. However, experience indicates that over time, the demand for larger satellites follows the supply of larger rockets. Therefore, even if priced at parity with U.S. launch vehicles, these new rockets could usher in a strong new competitive challenge to medium and intermediate U.S.-based launch service providers. This, however, could be offset by the impact of trade agreements and reliability concerns.

Other rationale considered by continued growth advocates includes:

- **Affordability:** Comparing the product of satellite power, bandwidth and satellite lifetime and dividing by cost, a very large "condominium" satellite can cost significantly less than a smaller spacecraft.
- **Power:** End user demand for more satellite power is increasing rapidly either for direct broadcast satellites (smaller dishes and better signal quality); for geosynchronous mobile communications satellites (more voice circuits and power hungry digital signal processing); and finally, for next generation broadband multimedia interactive satellites (higher data rates, smaller dishes, and better signal quality).
- **Orbital Congestion:** The geosynchronous orbital arc is steadily becoming more crowded and fewer transmit frequencies are available for use. This can result in heavier spot beam antennas and frequency reuse (for Ka-band satellites) or demanding orbital separation requirements (and ultimately larger and more capable satellites) for co-coverage C- and Ku-band applications.

Another difference of opinion within the working group relative to growth of payload mass was their forecast of the relative commercial success of electric propulsion for orbit raising. Some group members believed that there had been, and would likely remain limited commercial interest in this technology. Others suggested that some, but perhaps not all commercial customers could stand to benefit from it. The group agreed, however, that while electric propulsion systems are currently in use for satellite station keeping, they have not significantly slowed the growth in payload mass. On the other hand, if electric propulsion for orbit raising proved commercially successful, it could reduce propellant mass significantly.

An implication of the Continued Mass Growth Model is the potential loss of market share by U.S. launch providers, given no current U.S. launch capability greater than 9,000 lbs.

### **Graphs and Calculations (Payload Mass)**

Both the stable and continued payload mass growth models are identical in several respects. For purposes of comparison, both models are based on the same average launch rate estimate from 1996 through 2010 (Figure 1.0 and Table 1.0) discussed earlier in the report. Likewise, both models are divided into three different payload mass categories: Medium, Intermediate and Heavy (Tables 2.1 and 2.2). Finally, both models contain the same estimate of Medium payloads to be launched in a given year, reflecting a general consensus within the group regarding the number of future launches in this weight category. This estimate therefore represents the sum of all five forecasts for this mass category divided by five.

The two payload mass distribution models differ thereafter. For example, the Intermediate and Heavy payload mass estimates for the continued mass growth model are based on the average of the two forecasts that suggest the most change in payload mass. Likewise, the corresponding Intermediate and Heavy payload mass estimates for the stable mass growth model are based on the average of the three remaining forecasts (Tables 2.1 and 2.2).



The "pie" chart (Figure 3.1) and the corresponding stacked "area" chart (Figure 3.2) were calculated as outlined below. The 1996-2010 averages are based on the corresponding sum of estimates covering the entire forecast period. Similarly, the annualized estimates (Figure 3.2) are based on year-by-year totals only. As stated earlier, the calculations are based on the five comprehensive commercial GTO forecasts.

The Uncertainty Band "ILV or HLV" portion of each graph reflects the difference between the two mass growth models, an average of 23%.

Number	Calculation Method
Total number of payloads	All 5 comprehensive forecasts divided by 5
MLV payloads	All 5 MLV forecasts divided by 5
HLV payloads	3 "Stable Payload Mass Growth" forecasts divided by 3
Uncertainty Band: HLV or ILV payloads	2 "Continued Payload Mass Growth" forecasts divided by 2 Less (HLV payloads)
ILV payloads	Total number of payloads Less (MLV + HLV + "HLV or ILV" payloads)

### Background

COMSTAC prepared the first commercial mission model in April 1993 as part of a report on commercial space launch systems requirements (reference 2). Each year since 1993, COMSTAC has issued an updated model. The process has been continuously refined and industry participation broadened each year to capture the most realistic portrayal of space launch demand possible. Thus, the COMSTAC mission model has been well received by industry, government agencies and international organizations.

1993: The first report was developed by the major launch service providers in the U.S. and covered the period 1992 - 2010. The report projected only modest growth in telecommunications markets based mainly on replenishment of existing satellites, with only limited new satellite applications.

1994: Key U.S. spacecraft manufacturers contributed to the 1994, report which represented an average of inputs by Hughes Space & Communications, Martin Marietta Astro Space and Space Systems Loral. The demand reflected an average of 17 payloads per year over the forecast period of 1994-2010, with some members of the spacecraft manufacturing community believing the mission model to be conservative.

1995: The Technology and Innovation Working Group was formally chartered to prepare an annual Commercial Spacecraft Mission Model Update Report (reference 3, 4). The organizations from which the market demand forecasts were requested was further expanded to include satellite operators, in addition to spacecraft manufacturers and launch service providers. The 1995 data contained sizable variations in projected launch demand with a significant degree of polarization around two differing viewpoints. Therefore, a two case scenario was adopted for the 1995 report. A "Modest Growth" scenario projected an average demand for launch of approximately 20 payloads per year over the period 1995 to 2010. A "Higher Growth" scenario forecasted the demand to be an average of 32 payloads per year. Both models included firm contracted missions, satellite operator's planned missions, growth, replenishment and attrition (replacement for launch or on-orbit failure, assumed to be 10% in total). The "High Growth"

case also included a segment called "unidentified growth" often based on proprietary information from the survey respondents.

In the 1995 model there was general agreement among the participants regarding the distribution of payloads among the different weight classes. In both the Modest and Higher Growth cases approximately 70% of the payloads were forecasted to be in the Intermediate category (4000 - 8000 lb.), with 15% each in the Medium (2000-4000 lb.) and the Heavy (>8,000 lb.) classes.

#### **Appendix 1 References**

1. "Space Transportation Markets", Arianespace, March 1996
2. COMSTAC Report, "Commercial Space Launch Systems Requirements - 28 April 1993", Office of Commercial Space Transportation, U.S. Department of Transportation, Washington, D.C.
3. Verner, Liipfert, Bernhard, McPherson and Hand letter, dated 10/18/94, A. Bondurant to P.N. Fuller
4. COMSTAC Report, "Commercial Spacecraft Mission Model Update - 18 May 1995", Office of Commercial Space Transportation, U.S. Department of Transportation, Washington, D.C.

Report of the  
COMSTAC Technology & Innovation Working Group

**COMMERCIAL SPACECRAFT MISSION MODEL UPDATE**

**May 1996**

**Appendix 2**  
**1996 - 1998 Near-Term Mission Model**

Commercial Space Transportation Advisory Committee (COMSTAC)  
Office Of Commercial Space Transportation  
Federal Aviation Administration  
U.S. Department of Transportation

### 1996 Mission Model - Near Term

Near Term Payload Launch Demand Forecast 1996 through 1998: A summary of the near-term 1996-1998 mission model individually identified by name is presented in Appendix 2. The table is divided into addressable commercial GTO spacecraft and non-commercial spacecraft that will potentially utilize the same commercial launch systems. The non-commercial spacecraft forecast includes payloads captive to national flag carriers. There has recently been an initial breakthrough of U.S. spacecraft manufacturers into this market, and there is speculation that the launch service segment of this market may eventually open to U.S. competition, although doubtful until beyond 2000. In the period through 1997, most launch procurement decisions have been made and the launch vehicle manifests have been established. Over this time period, satellite lead times are striving for 12-18 month delivery cycles, while launch vehicles deliveries remain closer to 24 months. Therefore, pressure continues for launch vehicle manufacturers to compress production and/or cycle times.

Note, however, that even in this near-term period complete unanimity was not reached due to differences in opinions on outcomes of expected demand including effects of double booking, program delays, etc. Therefore, the ground rules that were adopted to arrive at the forecast presented are stated below:

- Published manifests of the launch service providers were used unless a failure event of other recognizable event has caused a delay.
- Where manifests do not exist, or where an event which caused a delay has occurred, the subgroup relied on the data source within the subgroup that most likely had the superior knowledge. For example, the McDonnell Douglas representative could modify the published manifest data for the Delta II, or a spacecraft manufacturer with knowledge of launch dates for an unrepresented launch system experiencing delays could provide the most up-to-date information.
- Where the spacecraft has been ordered, but the launch company has not been selected, the date the operator contracted for satellite readiness was used.
- Plans of existing satellite service operators were used as available.
- Plans of new or potential operators (i.e. growth in demand) were subject to the judgment of the individual subgroup members. It is this factor that led to the dispersions around the average forecast beginning in the year 1998.

# Appendix 2: 1996 Near-Term COMSTAC Commercial GTO Mission Model

	1995	1996	1997	1998	TOTAL	3 Year Average Rate
TOTAL =	18	30	34	48	114	38.0
Arianespace	9	14	17	9	42	14.0
HLV	1 Intelsat 706A	1 Intelsat 707A 1 Intelsat 709	1 Intelsat 801 1 Intelsat 802 1 Intelsat 803	1 Intelsat 804		
ILV	1 Brazil-BrazilSat B2 1 Eutelsat-8 Fo-Hotbird 1 1 India-Insat 2C 1 Japan-NStar CS-A 1 Luxembourg-SES Astra 1E 1 US-AT&T Telesat 402R 1 US-Hughes DBS 3 0 US-PAS 3R 1 US-PAS 4	1 ArabSat 2A 1 Argentina-Nahuel 3 1 Canada-TM MStar M1 1 India-Insat 2D 1 Indonesia-Palapa C2 1 Italy-Italsat 2 1 Japan-NStar CS-B 1 Thailand-Thaicom 3 1 Turkey-Turksat 1C 1 US-Echo Star 2 1 US-PAS 3R	1 ArabSat 2B 1 Brazil-BrazilSat B3 1 Egypt-NileSat 1 1 Eutelsat-301 1 Eutelsat-Hotbird 3 1 Eutelsat-Hotbird 4 1 Inmarsat 304 1 Laos-LStar 1 1 Sweden-Sinus 2 1 US-GE Americom GE2 1 US-PAS 7 1 US-PAS DTH 6	1 Eutelsat-302 1 India-Insat 2E 1 Inmarsat 305 1 Laos-LStar 2 1 US-World Space 1 1 US-World Space 2		
MLV	0 Malaysia-MedSat 1	1 Israel-Amos 1 1 Malaysia-MedSat 1 1 Malaysia-MedSat 2	1 Indonesia-Indostar 1 1 Japan-BSat 1A	1 Japan-BSat 1B 1 UK-SkyNet 4E		
Atlas	5	6	4	3	13	4.3
HLV	1 Intelsat 704 1 Intelsat 705			1 Intelsat 805A 1 Intelsat 806A		
ILV	1 AMSC-MSat M2 1 Hughes-Galaxy 3R 1 Japan-JSat 3	1 Eutelsat-Hotbird 2 1 Indonesia-Palapa C1 1 Inmarsat 301 1 Inmarsat 303 1 US-GE Americom GE1 1 US-TCI Tempo Sat 2	1 Hughes-Galaxy 8i 1 Japan-JSat 4 1 Japan-SCC-Superbird C 1 US-DBSC 1	1 US-MCI/News Corp 2		
MLV						
Delta	1	2	2	0	4	1.3
HLV						
ILV	1 KoreaSat 1 0 KoreaSat 2	1 KoreaSat 2 1 US-Hughes Galaxy 9	1 Norway-Thor 2A 1 UK-SkyNet 4D			
Long March	3	3	3	0	6	2.0
HLV	0 Intelsat 708A	1 Intelsat 708A	1 China-APStar 2R			
ILV	1 China-APStar 2 1 China-Asiasat 2 1 US-Echo Star 1		1 Argentina-Nahuel 4 1 Philippine-Mabuhay 1			
MLV		1 China-APStar 1A 1 China-Chinasat 7				
Proton	0	3	5	0	8	2.7
HLV			1 Luxembourg-SES Astra 1G 1 US-AT&T Telesat 5			
ILV		1 Inmarsat 302 1 Luxembourg-SES Astra 1F 1 US-TM TempoSat 1	1 China-Asiasat 3 1 US-MCI/News Corp 1 1 US-PAS 5			
Zenit	0	0	0	0	0	0.0
HLV						
ILV						
TBD	0	0	5	36	41	13.7
HLV			1 Luxembourg-SES Astra 1H 1 Unnamed	1 China-APMT 1 1 Indonesia-ACes 1 1 US-Hughes Galaxy 11 1 US-PAS 8 1 Saudi Arabia-Satphone 1 Not ordered 1 Luxembourg-SES Astra 2A Not ordered 1 US-AT&T Telesat 6 Not ordered 1 US-PAS 9		
ILV		1 Eutelsat 30x 1 US-GE Americom GE3 Not ordered 1 US-GE Americom GE4	1 China-Asiasat 5 1 Singapore-ST 1 1 US-DBSC 2 1 US-Hughes Galaxy 10 1 US-Orión 2 Not ordered 1 Canada-Telesat DTH 1 Not ordered 1 Canada-Telesat DTH 2 Not ordered 1 China-APStar 3 Not ordered 1 Mexico-Morelos 3/2R Not ordered 1 Norway-Thor 2B Not ordered 1 Philippine-Mabuhay 2 Not ordered 1 US-GE Americom GES Not ordered 1 zAffinity-1996 Relaunches Not ordered 1 ArabSat 2C Not ordered 1 China-Asiasat 4 Not ordered 1 Egypt-NileSat 2 Not ordered 1 Indonesia-Palapa C3 Not ordered 1 Japan-JCSat 1R Not ordered 1 Japan-Superbird D Not ordered 1 Sweden-Sinus 3 Not ordered 1 Thailand-Thaicom 4 Not ordered 4 US-Unnamed	1 Eutelsat-Hotbird 5 1 Singapore-ST 1 1 US-DBSC 2 1 US-Hughes Galaxy 10 1 US-Orión 2 Not ordered 1 Canada-Telesat DTH 1 Not ordered 1 Canada-Telesat DTH 2 Not ordered 1 China-APStar 3 Not ordered 1 Mexico-Morelos 3/2R Not ordered 1 Norway-Thor 2B Not ordered 1 Philippine-Mabuhay 2 Not ordered 1 US-GE Americom GES Not ordered 1 zAffinity-1996 Relaunches Not ordered 1 ArabSat 2C Not ordered 1 China-Asiasat 4 Not ordered 1 Egypt-NileSat 2 Not ordered 1 Indonesia-Palapa C3 Not ordered 1 Japan-JCSat 1R Not ordered 1 Japan-Superbird D Not ordered 1 Sweden-Sinus 3 Not ordered 1 Thailand-Thaicom 4 Not ordered 4 US-Unnamed		
MLV			Not ordered 1 Malaysia-MedSat 3			

# Not Included in COMSTAC Near-Term Commercial GTO Mission Model

	1995	1996	1997	1998	TOTAL	3 Year Average Rate
TOTAL =	23	26	40	30	96	32.0
<b>Ariane</b>	1 ESA-ERS 2 1 ESA-ISO 1 France-Helios 1 1 France-Telecom 2C	1 ESA-European Cluster 1 ESA-Recovery Module 1 France-Telecom 2D	1 France-Spot 4 1 Eumetsat-Meteorat(MOP 4)	1 ESA-Artemis 1 1 France-Helios 1B		
<b>Atlas</b>	1 ESA-SOHO 1 US-AF-DSCS 3-05 1 US-N-UHF/EHF F04 1 US-N-UHF/EHF F05 1 US-N-UHF/EHF F06 1 US-NASA/NOAA-Goes J	1 ESA-SAX-Astronomy 1 US-N-UHF/EHF F07	1 US-AF-Cali UP MLV-7 1 US-AF-DSCS 3-06 1 US-NASA/NOAA-Goes K	1 US-N-UHF/EHF F08 1 US-N-UHF/EHF F09 1 US-N-UHF/EHF F10 1 US-NASA-EOS AM		
<b>Delta</b>	1 Canada-Radarsat 1 US-NASA-XTE	1 Iridium 01 - 5 1 Iridium 02 - 5 1 US-AF-GPS 2-Block 2-07 1 US-AF-GPS 2-Block 2-10 1 US-AF-GPS 2R-01 1 US-AF-Midcourse Space Exp 1 US-NASA-Mars Global Surv 1 US-NASA-MESUR Pathfinder 1 US-NASA-NEAR 1 US-NASA-Polar	1 GlobalStar 1 - 04 1 GlobalStar 2 - 04 1 Iridium 03 - 5 1 Iridium 04 - 5 1 Iridium 05 - 5 1 Iridium 06 - 5 1 Iridium 07 - 5 1 Iridium 08 - 5 1 US-AF-Argos P91 1 US-AF-GPS 2-Block 2-08 1 US-AF-GPS 2-Block 2-09 1 US-AF-GPS 2R-02 1 US-AF-GPS 2R-03 1 US-NASA-ACE	1 US-AF-GPS 2R-04 1 US-AF-GPS 2R-05 1 US-AF-GPS 2R-06 1 US-AF-GPS 2R-07 1 US-NASA-Landsat 7 1 Iridium 09 - 03 1 Iridium 10 - 03 1 US-AF-SMITS/Bright Eyes		
<b>Japan</b>	1 Japan-GMS 1 Japan-SFU	1 Japan-ADEOS	1 Japan-Comets 1 Japan-TRMM 1 Japan-ETS-7			
<b>Long March</b>		1 China-DFH 302 1 China-Fengyun 2A	1 China-DFH 303 1 China-Orientstar 1 1 China-Sinostar 1	1 Brazil-CBERS 1 1 China-DFH 401 1 China-DFH 402 1 China-Sinostar 2 1 GlobalStar 01 - 12		
<b>Proton</b>	1 Russia-GALS 2	1 Russia-Express 02 1 Russia-Gorizont 31 1 Russia-Gorizont 31R 1 Russia-Gorizont 32	1 Iridium 01 - 7 1 Iridium 02 - 7 1 Iridium 03 - 7 1 Russia-Express 03 1 Russia-Express 04 1 Russia-Yamal 1 Russia-Yamal	1 Russia-Express 05 1 Russia-Express 06 1 Russia-Express 07 1 Russia-GALS 3		
	7 Domestic Requirements	3 Domestic Requirements	5 Domestic Requirements	6 Domestic Requirements		
<b>Zenit</b>			1 GlobalStar 01 - 12 1 GlobalStar 02 - 12 1 GlobalStar 03 - 12			
	1 Domestic Requirements	1 Domestic Requirements	7 Domestic Requirements	7 Domestic Requirements		
<b>TBD</b>				1 ICO #01		

Note LEO/MEO Missions count multiple spacecraft as single requirement missions.

## Legend:

1995 Launch Services postponed from 1995 to 1996 due to previous Launch Vehicle failure

Name Launch Mission Failed

Name Commercial LEO or MEO Launch Mission - Usually involves multiple spacecraft

Name Spacecraft not included in all members models

1 Spacecraft provides commercial communication services, possibly involves western manufacturer, captive launch

	1995	1996	1997	1998	TOTAL	3 Year Average Rate
TOTAL SPACECRAFT LAUNCHED=	41	56	76	78	210	70.0
Leo Constellation clusters counted as one		8	57	15	80	26.7

## Long March 2C

Small		1 Iridium 01 - 2 1 Iridium 02 - 2 1 Iridium 03 - 2	1 Iridium 04 - 2 1 Iridium 05 - 2 1 Iridium 06 - 2
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Report of the  
COMSTAC Technology & Innovation Working Group

**COMMERCIAL SPACECRAFT MISSION MODEL UPDATE**

**May 1996**

**Appendix 3**  
**1988 - 1995 Mission Model - History**

Commercial Space Transportation Advisory Committee (COMSTAC)  
Office Of Commercial Space Transportation  
Federal Aviation Administration  
U.S. Department of Transportation

Average  
Rate14 1.6

15	1.9
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06

8 10

8/14/96



# Appendix 3: COMSTAC Mission Model - History

## Not Included in Commercial GTO Mission Model - Utilized Commercial Launch Service Vehicles

	1988	1989	1990	1991	1992	1993	1994	1995	TOTAL	Average Rate
TOTAL =	11	13	15	8	14	14	10	15	100	11.1

### Airline

ESA-Meteosat 3	ESA-Cyprus 1	France-Spot 2	ESA-ERS 1	France-Telecom 2B	Eumetsat-Meteosat 6	ESA-ERS 2
France-IDF 1	ESA-Hippocras	France-IDF 2	ESA-Meteosat 5	NASA-TOPEX	France-Spot 3	ESA-ISO
France-Telecom 1C	ESA-Meteosat 4		France-Telecom 2A			France-Hellas 1
						France-Telecom 2C

### Atlas

US-AF DMSP F09	US Navy Philocom 8	US-AF DMSP F10	NOAA 12	USAF-DSCS 3 B01	NOAA 13	USAF DMSP F12	ESA-SOHO
US-NOAA 11	US-AF Stockport	US-AF Stockport	US-AF DMSP F11	USAF-DSCS 3 B02	USAF-DSCS 3.03	USAF DMSP F03	US-AF DSCS 3.05
	US-NASA/AF CRESS				USAF-DSCS 3.04	US-NOAA 14	US-NASA/NOAA Goes J
					US-UHF F01	US-NOAA Goes 8	US-Navy UHF/EHF F04
					US-UHF F02		US-Navy UHF/EHF F05
							US-Navy UHF/EHF F06

### Delta

US-AF DM43-ItustVecEx	US-AF Cos Bigard Exp	Germany-Rosat-X Ray	US-AF GPS Navstar 11	Japan-Geosat	US-AF GPS 2 Bk 2 01	NASA Wind	Canada-Radarsat
US-AF Delta Star	US-AF GPS Navstar 06	US-AF GPS Navstar 07	US-AF GPS Navstar 12	US-AF GPS Navstar 13	US-AF GPS 2 Bk 2 02	US-AF GPS 2 Block 2 06	US-NASA XIE
US-AF GPS Navstar 01	US-AF GPS Navstar 08	US-AF GPS Navstar 09	US-AF GPS Navstar 14	US-AF GPS Navstar 15	US-AF GPS 2 Bk 2 04		
US-AF GPS Navstar 02	US-AF GPS Navstar 10		US-AF GPS Navstar 16	US-AF GPS Navstar 17	US-AF GPS 2 Bk 2 05		
US-AF GPS Navstar 03	US-AF GPS Navstar 05		US-AF GPS Navstar 18				
US-AF GPS Navstar 04							
US-AF GPS Navstar 05							

### Titan II

US-AF Titan 2	US-AF Titan 2	US-NASA Clementine
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### Japan

Japan-CS 3A	Japan-GMS 4	Japan-BS 3A	Japan-ERS	Japan-EIS 6	Japan-GMS
Japan-CS 3B		Japan-MCS 1B			Japan-SFU

### Proton - (Western Use Only)

Russia-Ramsat Express	Russia-GALS 2
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### Long March

China-DH 201	China-DH 203	China-DH 204	China-DH 301
China-DH 202			

**Not Included in Commercial GTO Mission Model - Did Not Utilized Commercial Launch Service Vehicles**

	1988	1989	1990	1991	1992	1993	1994	1995	TOTAL %	Average Rate
4	9	6	7	7	3	4	6	48	60	60
TOTAL =	4	9	6	7	7	3	4	6	48	60

## Shuttle

[illegible]

### Man III & IV

[illegible]

**Legend:**

☐ Spacecraft failed to reach operating status as planned

Spacecraft partially failed after achieving operating status

TOTAL SPACECRAFT LAUNCHED=		24	30	41	29	38	27	32	39	260	32.5
FAILURES	2	2	2	3	2	3	3	5	1	21	2.6
	8.3%	6.7%	6.7%	7.3%	6.9%	7.9%	11.1%	15.6%	2.6%	8.1%	8.1%

## Statistical Summary of Addressable GEO Spacecraft MANUFACTURERS

TOTAL LAUNCHED=		9	8	16	14	17	10	18	18	112	100%	14.0
LAUNCHER												
US =	0	1	8		6	6	2	4	6	33	29%	4.1
EUROPEAN =	9	7	9		9	9	8	12	71	63%	8.9	
OTHER =	0	0	1		2	2	0	2	3	6	7%	1.0
SPACECRAFT												
US =	6	5	12		11		8	14	16	78	70%	9.8
EUROPEAN =	2	3	5		5		2	4	1	28	25%	3.5
OTHER =	1	0	1		1		1	0	1	7	21%	0.9

## OPERATORS

	US =	0	4	2	5	3	6	30	27%	3.8
EUROPEAN =	3	4	5	5	3	3	2	29	26%	3.6
WESTERN HEMI	0	0	0	2	0	1	1	6	5%	0.5
INTERNATIONAL	1	2	3	4	3	1	3	19	17%	2.4
ASIAN	1	2	6	1	6	2	6	28	25%	3.5

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